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Biodiversity and sustainable agriculture

14th - 17th August 1996
Ekenäs, Sweden

A workshop arranged by the Swedish Scientific Council on Biological Diversity focusing on the importance of biodiversity for sustainable agriculture.

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SWEDISH SCIENTIFIC COUNSIL
ON BIOLOGICAL DIVERSITY

The author is solely responsible for the text which does not necessarily reflect the views of the Scientific Council on Biological Diversity or the Swedish Environmental Protection Agency.

Biodiversity and sustainable agriculture

14th - 17th August 1996 at Ekenäs, south of Stockholm, Sweden

A workshop arranged by the Swedish Scientific Council on Biological Diversity focusing on the importance of sustainable use of agroecosystems for the conservation of biodiversity

Background

At the first Conference of the Parties (COP) to the Convention on Biological Diversity (CBD), the Parties set out the substantive agenda for the coming sessions (1995-1997) of the COP. Following a proposal by Sweden, a "major ecosystem" will be treated at each session of COP. The 1995 session dealt with marine and coastal ecosystems, and the 1996 session will deal with agroecosystems. Agroecosystems was also on the agenda for the second meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) under the Convention, which was held 2-6 September in Montreal.

In 1993 the Swedish Parliament adopted a Strategy for Biological Diversity. As a part of the strategy, a National Scientific Council on Biological Diversity was established, with a mandate to serve as a link between the Government and the Scientific Community and to prepare the Swedish participation in SBSTTA. The Council was asked by the Government to arrange a workshop as a part of the preparations for the deliberations of the agenda point on Agroecosystems at the SBSTTA meeting. In 1995, the Council arranged a workshop in preparation for the discussions on marine and coastal biodiversity under the CBD. The Swedish Government found that workshop report very useful both in SBSTTA and at the COP 2.

The aim of the workshop was to prepare a background document on agrobiodiversity as an input to the second meeting of the Subsidiary Body on Scientific, Technical and Technological Advise (SBSTTA) of the Convention on Biological Diversity. However, due to the short timespan between the workshop and the SBSTTA meeting, a report reviewed by the participants of the workshop could not be presented. Instead, a Swedish paper consisting of conclusions and recommendations from the worskhop was presented at the SBSTTA meeting.

The present paper is the official report of the workshop, reviewed by the participants. It consists of a summary of conclusions and recommendations, abstracts of the invited lectures, and reports of the working groups discussing the focal questions of the workshop (see programme).

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Workshop programme:

Wednesday, 14 August

Breakfast	
Arrival	
12.00	Lunch
13.00	Opening of the workshop - Ulf Svensson, Ministry of Agriculture Aim of the workshop and practical information
13.30	Lectures introducing subject 1"The relationship between historical land use, cultural landscape diversity and the conservation of biodiversity" Trygve Berg - Land use, cultural landscape and the conservation of biodiversity
14.15	Coffee/ tea
14.45	Lecture introducing subject 2 "Habitats for wild species within agroecosystems" Dan Simberloff - Agriculture and the impact of nonindigenous species on native biodiversity Karl Hurle - Weeds: the unliked part in agroecosystems
16.00	Start of discussions, subject 1 & 2
18.00	Dinner
19.00	Evening walk Informal discussions & pub

Thusday, 15 August

Breakfast	
8.30	Lecture by Mark Prein
9.00	Group discussions, subjects 1 & 2
12.00	Lunch
13.00	Excursion to a nearby open air museum and centre for conservation of traditional crop species and domestic animals
18.00	Dinner at the open air museum
22.00	Back at Ekenäs

Friday, 16th August

Breakfast

8.30 Lectures introducing subject 3 "Use of chemicals (including nutrients) in agriculture and its impact on biodiversity"
Peter Kenmore - How Asian and African farmers conserve agricultural biodiversity, minimize insecticide use, and increase profits.
Victor Blandon Rivera - Effects of different cultural practices on the biodiversity of weed species in a sustainable agricultural context.

10.00 Coffee/ tea

10.30 Lectures introducing subject 4 "Towards sustainable agriculture - how to achieve realistic scenarios in short and long term perspectives?"
V. Ghandimathi - Sustainable agriculture: An overview of issues, efforts and constraints
Larry Harrington - Diversity by design: Conserving biological diversity through the indirect as well as the direct consequences of improved productivity and sustainability in agroecosystems.

11.30 Lectures introducing subject 5 "Conservation and use of domesticated speices"
Marcio de Miranda Santos - The conservation and use of genetic resources of domesticated plant species

12.00 Lunch

13.00 Group discussion, subjects 1-2 continued

14.00 Group discussion, subjects 3-5

15.00 Coffee/ tea

15.30 Group discussions, subjects 3-5, continued

18.00 Dinner

19.00 Group discussions, subjects 3-5 continued

Informal discussions and pub

Saturday, 17th August

Breakfast

8.30 Group discussions, subject 3-5 continued

10.00 Lecture by Sergey Bobylev - Perspectives and problems of sustainable agriculture in Russia

10.30 Report and discussion, subjects 1-2

12.00 Lunch

13.00 Report and discussion, subjects 3-4

15.00 Coffee/ tea

15.30 Report and discussion, subject 5

16.30 Organization of the workshop report

16.45 Summary and closing of the workshop

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Ekenäs Statement on Biodiversity and Sustainable Agriculture - Summary of Conclusions and Recommendations from a Workshop of International Experts

The Convention on Biological Diversity should consider Agricultural Biodiversity as a key focal area. The Third Conference of the Parties should establish a Three-Year Global Program of Action, the Buenos Aires Mandate, on Agricultural Biodiversity.

Modern industrialised agriculture, including the Green Revolution, has achieved major cereal production gains but at preconditions of shaping mostly uniform environments using a limited number of widely adapted crop varieties and high inputs. This technological approach, the agroindustrial paradigm, is creating a multitude of environmental problems. The adverse off-site effects of this industrial agriculture include degradation of habitats by destruction of biotic and abiotic resources as well as threats to the natural resource base to agriculture, and socioeconomic problems created by destruction of the local resource basis.

Biological diversity has not been adequately considered neither on the ecosystem level, nor on the species and the genetic levels. It is generally acknowledged that soil, plant, and animal biodiversity has been substantially reduced. Not only habitats, species and genes are being lost, but equally important knowledge in farming communities about their cultivars, environments, and management strategies including traditional and indigenous knowledge. Scientists are increasingly recognizing the values of biological diversity and local knowledge, for the integrity and functions of agroecosystems. The inseparable links beween 1) the use of wild and domestic biodiversity at all levels - ecosystems, species and genes -, 2) local knowledge, and 3) sustainable high-yielding agricultural production must be understood.

It should be stressed that the current technological approach to agroecosystem management and food production has had an extremely short duration, approx. 50 years. The already documented adverse environmental effect, and the emerging threats to the natural resoruce base to agriculture offer no assurance for sustainability. The history of agriculture is over 10.000 years. The time perspectives for sustainability of agricultural ecosystems must be of a similar dimension.

Current technological agrosciences support the technical change paradigm, dominated by the effort to modify the local environments through high use of inputs resulting in low-diversity habitats and ecosystems in order to fit genetically similar, but high-yeilding cultivars. This approach does non sufficiently reckon/ consider how farmers view their natural environments in both time and space, how they fit genetic resources and cultural practices to diverse ecosystems to obtain sustainability in food production. As a result many new technical interventions relate poorly to farmers' objectives and resources, and fit poorly into their agroecosystems.

The biotic component of the soil resource is still poorly known. Erosion of diversity in domesticated species, is accompanied by a related loss of biological diversity in agricultural soils. Increasingly, agricultural systems are loosing their diversity. The huge dimension of unsustainable use and management of soil resources is leading to soil compaction, decrease and loss of soil organic matter, and soil erosion. This development, in combination with excessive use of agrochemicals and unsustainable irrigation practices, is leading to large-scale losses of agricultural biodiversity thereby undermining the long-term productivity of agricultural ecosystems.

This general situation differs in nature and degree in the varying historical, agricultural, economic, and cultural settings of Europe, industrializing and agrarian Asia, Africa, Australia and the Americas. The fundamental problem, nevertheless, of inadequate articulation between the perspectives of farmers' communities and those of the modern scientific and policy communities is recognized throughout.

Actual and potential knowledge about local agroecosystems generated by farmer communities is a key to optimizing the management of those agroecosystems. This knowledge needs to be maintained as a living management process in local communities, as well as being documented for further use.

Much of the agricultural production, agricultural practices and not least the local breeding activities are performed and maintained by women in local societies. The role of women for maintaining those skills and knowledges is of fundamental importance.

The major challenge facing us today is to establish an alternative, **biodiversity paradigm** based on the following major elements:

1) change the current techno-industrial approach of ecosystem uniformity into production practices based on local biotic and abiotic conditions;

2) maintain and mobilise local knowledge of farmers and of farmers communities in food production in order to identify, maintain, develop and use sustainably the components of biological diversity in agricultural ecosystems.

The constraints to meeting this challenge are not only technical but also of a policy nature.

This expert consultative workshop proposes two principles for future thinking on biodiversity and sustainable agriculture; the Agroecosystem principle and the Local community empowerment and farmers participation principle.

I. Agroecosystem Principle:

Agroecosystems are subject to the same processes as natural ecosystems, and they are powered by solar energy for the production of plant biomass. Also, they are always subject to the same physical processes of weathering, erosion, and nutrient circulation. The major difference between natural ecosystems and agro-ecosystems is that the latter are manipulated in various degrees to maximize the production of one aspect of plant biomass

- the cultivated crops. There exists a gradient between agro-ecosystems and systems less influenced by human activities, as well as between domesticated and wild species. Agro-ecosystems must be allowed to evolve in terms of technology (agricultural practises) and use of biological resources. Their future production sustainability depends crucially on both local knowledge and biological diversity being maintained.

Current practises for the exchange and utilization of genetic resources are leading to a reduced genetic variability of domesticated species. The sustainable use of more diverse, adapted and productive genetic resources should be promoted in the spirit of the *Biodiversity Paradigm* for the development of sustainable agroecosystems, intergrated resource managment and future food security. Desisive actions to implement the Leipzig Global Plan of Action for the conservation and sustainable use of Plant Genetic Resources for food and agriculture is of crucial importance. Also implementation of a Global Stragety for the Management of Farm Animal Genetic Resources is of importance.

Rapid erosion of both cultural- and biological diversity poses a long term threat to human food security, even if there is in the near to medium term no global problem of food supply. However, agroecosystems which presently are highly productive, with strongly reduced biological diversity, may not be sustainable. Conversely, for some people and some areas agriculture has not developed the potential to deliver income, employment and food security. For these people and areas, the lack of productivity in agriculture also is associated with degradation of biodiversity.

The globalisation of markets and the standardisation associated with commercial processing industries contribute to the erosion of local biodiversity. Urbanisation is contributing to the erosion of cultural diversity and creating human societies separated from direct experience of agroecosystems and the understanding of the relationships between food production and environmental resources, including biological resources.

Recommendations:

1. Develop integrated resource management (IRM) to achieve sustainable high-yielding agroecosystems. IRM comprises the strategies of adapted genetic resources and of lower external input, and sustainable agriculture (LEISA), integrated farming systems and organic farming, in ways that foster improved productivity and the ability to meet human needs as well as the conservation and sustainable use of the natural resourcs base for soils, water resources and biological diversity. The following elements should be highlighted and intergrated:

- Participatory land use planning where landscape ecological dimensions should be focused.

- Sustainable management of the soil ecosystems including their bioloigcal diversity.

- Integrated Plant Nutrition Management and Integrated Pest Management (IPM) with an emphasis on nutrient recirculation at the agroecosystem level including crop rotation and inter cropping .

- Promote intergration of sustainable agriculture and aquaculture.

- Promote interaction between rural and urban areas in terms of recirculation of nutrients within the framework of the development of ecocycle societies.

2. Promote sustainable use of more diverse and productive agro-genetic resources:

- Communicate the central importance of basing sustainable agriculture development on locally adapted genetic resources.

- Promote farmers' needs and rights to exchange, select, breed, use, and sell local varieties.

- Allow and encourage pluralism and flexibility in seed regulatory frameworks to permit active farmers involvement in exchange, selection, breeding, use and sale. Support and promote the exchange of germplasm among farming communities.

- Promote the characterization of genetic resources and of agro-ecosystems to understand development paths and improve the measure to improve sustainablility.

- Promote participatory selection of varieties with the full involvement of breeders, farmers and extensionists in order to promote the rapid and targetted dissemination of genetic materials and to increase the motivation of extension field staff.

- Re-examine national seed release regulations and, when necessary, modify them so as to:
i) permit multiplication and dissemination of segregating plant populations to allow further deelopments in farmers fields;
ii) revise variteal release criteria to include information from farmer assessments;
iii) remove criteria which require broad geographical adaptability at the expense of fitting into local ecological conditions so as to ensure the release of material with superior performance in specific environments.

- Promote unrestrained availability of germplasms of crucial importance to food security to bona fide users including farmers for research and development purposes.

- Urgently develop and conclude international agreements for the exchange of genetic resources for food and agriculture, in accordance with the Convention on Biological Diverity, in order to encourage a broader exchange of genetic resources.

- Encourage the development of national programmes to commit resources towards the integration of in-situ on-farm and ex-situ conservation activities.

- Support farmers' efforts to establish networks for the on-farm conservation of genetic resources. Such support should facilitate communication and linkages with ex-situ conservation systems, re-introduction of material as necessary, development of locally adapted genetic resources, and creation of working linkages with participatory selection

breeding activities

- Promote the establishment of genetic in-situ reserves for relatives of domesticated species threatened with extinction.

- Integration will involve the two-way exchange of materials as well as information on germplasm characters and seed technologies adapted to local requirements.

- Public institutions must promote and continue to conduct and fund breeding activities, in particular efforts to broaden the genetic base of breedingg material, to provide a counter balance to the growing power of private sector firms and to ensure that social goods continue to be provided.

- Identify gaps in current collaboration for the conservation and utilization of genetic resources and promote collaboration where significant gaps occur. Priority should be given to species which have a wide geographical distribution, which reflect a high level of germplasm interdependence and which have global significance as food staples.

- Actively implement the Leipzig Global Plan of Action with an emphasis on action to promote farmers participation, the develpment of the rights of farmers, the creation of national intergrated programs for in-situ, on farm and ex-situ conservation of plant genetic resources for food and agriculture and action to broaden the genetic base of breeding material.

- Promote the implementation of the

- Invite the FAO to speed up the negotiations on the harmonization of the International Undertaking on Plant Genetic Resources with the Convention on Biological Diversity, and in that context to promote the realisation of Farmers' Rights and address the issue of collections of plant genetic resources aquired before the entry into force of the Convention of Biological Diversity.

3. Other activites in support of the Agroecosystem Principle:

- Promote public awareness of cultural and biological diversity as essential for sustaining food supplies and productive agriculture.

- Document, acknowledge, and provide open access to knowledge about existing agroecosystems, technologies, and practices, while ensuring fare and equitable sharing of the benefits derived from use of such knowledge.

- Analysis of risks and benefits of changes of agricultural practices should form components of Environmental Impact Assessment Analysis. Both spatial and temporal time scales should be comparable.

- Encourage research and technologies in food processing that would promote a broader utilisation of crops of low commercial interest.

- Support as a matter of urgency the development of tools and procedures for monitoring, and indicators of agroecosystem sustainability, in collaboration with farmers and other resource users.

- Promote a wide range of rural activities to generate employment and incomes, particularly when these may be valuable complements to agricultural production as such.

- SBSTTA should carry out a major assessment of adverse impacts of unsustainable agricultural practises on bioloical diversity to provide for a strong scientific basis for measures to promote sustainable use of agricultural biodiversity.

II. Local Community Empowerment Principle:

It is increasingly beeing acknowledged that the skills and practises farmers use in maintaining diversity in their fields and pastures, particularly outside conventional high input farming, is essential for agricultural sustainability and maintenance of biological diversity. These knowledge systems are not sufficiently documented and understood by the scientific community.

There is limited experience of pooling farmers' and scientists' knowledge and skills through collaboration in the development of new knowledge, technologies and practices. Recent initiatives demonstrate that the potential and the pay-off of participatory plant and animal breeding are considerable and merit further exploration and investment. Analogous examples in recent participatory agricultural science demands a shift towards the ***biodiversity paradigm***.

This shift will empower farmers to solve specific community-identified problems, energize scientists and extension staff through more stimulating relationships with farmers' communities, and open significant opportunities for sustainable food production based on local community empowerment and the sustainable use of biological resources.

Recommendations:

1. Promote greater and earlier farmer involvement in defining research priorities, approaches and evaluation of research for sustainable agriculture. To achieve this, forums could be set up and maintained for farmers, researchers, and extension workers to meet, discuss, debate on a "level playing field" that creates an atmosphere for the two-way flow of information and promotes a dynamic and truly participatory process.

2. Promote interaction and exchange of experience between farmers, researchers and extension staff to facilitate more rapid and widespread adoption of productivity-enhancing resource-conserving practices

3. Support further exploration and development of the contribution of Farmer-Scientist collaboration in plant and animal selection and breeding, and in community- and farm-level curatorship of genetic resources and agricultural landscapes. Support farmer-to-farmer exchange of information and genetic material.

4. Promote institutional changes to allow pluralism in the provision of services to farmers and decentralisation of public extension and development services. Support mechanisms which increase the accountability of extension and development service providers to farmers.

5. Introduce policies to foster sustainable and productive use of common property resources - policies that govern common property management (community grasslands, forests, groundwater reserves etc.) can be particularly useful in instances where collective action is needed to achieve sustainable resource use.

6. Introduce policies to govern the relationship among land owners and tenants, where tenancy or access relationships discourage productive and sustainable land use. Promote representation of NGOs and environmental groups and farmers' organizations in policy making at national levels.

Conclusions

FAO, CGIAR, UNESCO, UNDP, the World Bank and other relevant govermental orgaisation should be invited to assist the Convention on Biological Diversity in supporting efforts by the parties to develop major elements of the ***Biodiversity Paradigm*** for sustainable agriculture. Special emphasis should be put on research and development of intergrated resource management practises and technologies in accordance with the Agroecosystem Principle. Active participation of farmers, including women farmers, and indigenous and local communites embodying traditional life styles, farm workers organisations, as well as other relevant non-governmental organisations should be a hallmark for all programs and projects in support ot the development of the ***Biodiveristy Paradigm***, thus implementing the local communities empowerment and farmer's participation Principle.

The Buenos Aires Mandate on Agricultural Biodiverisy and the Five-year Global Program of Action should be submitted to the Interim financial mechanism of the CBD as policy guidance in the field of agricultural bioloigcal diveristy.

The Leipzig Global Plan of Action should form an integrated part of the Buenos Aires Mandate. Support of its implementation from the Interim Financial Mechanism of the Convention should be guided by the priorities introduced in the Mandate.

LECTURES

Land use, cultural landscape and the conservation of biodiversity

Trygve Berg
Noragric, Ås, Norway

The Convention on Biological Diversity assigns different conservation strategies for wild and domesticated species. "The wild species need to be protected and the domesticated species need to be managed". However, cultural landscapes all over the world harbour a great number of semidomesticated or protected species. Those species are not domesticated, but may still depend on human management for their survival. Also other wild species in cultural landscapes depend on an environment that is modified by human beings.

Conservation strategies often tend to foster a numerical rather than a qualitative valuation of diversity. In nature, species-rich ecosystems attracts most of the attention. And conservation strategies of domesticated biodiversity focus on areas with many varieties, the so-called gene centres. Measure of success is number of varieties salvaged in gene banks. The paper discussed these two aspects of biodiversity; dependency on environments, and qualitative rather than numerical valuation.

To some extent most terrestrial environments are modified by human beings. Human interference is so old that evolution has brought about a genetic adaptation to such environments. This adaptation has in many cases proved to be a pre-adaptation for domestication and has produced enormously valuable plant genetic resources for food and agriculture.

Conservation of these resources depend on how cultural landscapes are managed. The decisive factor is how local people live with and interact with the biological resources in their environment.

Agriculture and the Impact of Nonindigenous Species on Native Biodiversity

Daniel Simberloff
Department of Biological Science, Florida State University, Tallahassee, Florida, USA

In at least three major ways, agricultural practices have damaged native biodiversity through the import and spread of nonindigenous species. First, some plants deliberately introduced as crops have become invasive pests, modifying habitat over vast expanses to the detriment of native plants and animals. These invaders include food, forage, and fiber plants. Nonindigenous agricultural plants also threaten native species with a kind of genetic extinction, as hybridization occurs between widely planted crops and narrowly distributed endemic species and subspecies.

A second threat to native biodiversity arises from the synergistic interaction between large, nonindigenous Eurasian grazers and weeds or deliberately planted pasture plants adapted to an intense grazing regime. In North America and Australia, nonindigenous annuals have been favored by grazers at the expense of native perennials, which are often restricted to small, isolated refuges like cemeteries or steep slopes, while enormous areas are dominated by the invaders. On islands, grazers and nonindigenous plants adapted to them have driven native plants to extinction. Even when grazing is subsequently restricted, restoration of rangeland is sometimes impossible because established stands of nonindigenous plant species cannot be invaded by the native plants they had displaced.

Biological control is the third major way in which agricultural introductions have harmed native biodiversity, and the full extent of this problem may not be recognized. Generalized vertebrate predators introduced for rat, rabbit, and beetle control in agricultural fields have often eaten non-target species, driving some to extinction. A predatory snail introduced to many islands to attack a snail pest of agriculture has caused the extinction of an entire endemic genus of land snails on one island and extinctions and population declines of other nontarget species on other islands. Often these impacts occur in pristine habitats far from agricultural fields. Insect parasitoids and predators introduced to control weeds and insect pests of agriculture have similarly damaged nontarget plants and animals, including endangered ones, but the extent of this impact is hotly debated. The fact that not too many cases of such damage are well documented may simply reflect the meagre monitoring effort for the vast majority of species of no economic import. The well-substantiated cases all involve an extraordinary amount of routine monitoring that would rarely be conducted for the great majority of species. The fact that most insects released for biocontrol have a narrow host range need not be comforting, because species evolve, and many biocontrol projects that were successful from an agricultural standpoint entailed new associations between host and natural enemy. The fact that a nonindigenous insect species can very rarely be extirpated once it has been introduced mandates great caution in biocontrol introductions plus much more extensive cost-benefit analyses and risk analyses than have usually been conducted.

Weeds: the unliked part in agroecosystems

Karl Hurle
Institut fur Phytomedizin, Universität Hohenheim, Stuttgart, Germany

Weeds are a natural part of agroecosystems. Many weed species have co-evolved with crops and depend on the way crops are cultivated. Weeds contribute to the biodiversity. In Central Europe about 300 wild plant species are considered as weeds. Weeds are defined as plants out of place or plants growing where they are not wanted. They compete with the crop for water, nutrients and light and therefore reduce crop yields. They interfere with harvest operations and are carrier and transmitters of pests and diseases of crops. For these reasons they are controlled.

The weed density and weed species composition in a field is never constant, but strongly influenced by tillage, supply of nutrients, date of sowing, vegetation period and shading intensity of the crop, and efficiency of control measures. Moreover, species composition is very much dependent on soil and climatic conditiions. In general there is a richer flora in low intensive than in high intensive agriculture, with nitrogen supply being a crucial factor. Various surveys show a reduction in the diversity of weed flora of arable land. in Germany e.g. the reduction was about 40% in the last 30 -50 years. In the same time the soil seed bank has decreased from about 300 000 to < 10 000, in some instances < 1 000 viable seeds/m2. Today, various weed species are extinct. Futhermore, narrow crop rotations or monoculture has led to rather one-sided weed floras with sometimes one single species contributing up to 80% of the total seed bank.

The loss of weed species is of a general concern. Weeds are a heritage of the cultural landscape and although they interfere with crop production there is a need for preserving them for ethical and aesthetical reasons and as a future gene resource.

For agriculture this is a conflict. Farmers rather would prefer a weedfree environment - in less developed crop production systems about 40% of the labour spent for cultivating a crop goes into weed control - and of course the primary function of agriculture is food production, not preservation of wild species. Futhermore until now it has not been proven that a rich weed flora is essential for sustainable agriculture. However, the attitude on weeds is changing. More and more weeds are looked at (at least certain species) as organisms which also have positive effects on plant production since they reduce soil erosion and leaching of nutrients, contribute to a richer soil microflora, and some species are hosts for predators. Additionally it is now well established that crops have not to be completely weedfree to achieve an optimum economic result, because of the costs of control (threshold concept). As a consequence today more weeds are tolerated than still some years ago.

In contrast to extensive crop production in intensive agriculture for the sake of high yields a high biodiversity of weed species cannot be achieved even not at low densities.

To compensate this lack of diversity in some countries conservation headland/ field margin programs are practiced where no agrochemicals are used and weeds are not controlled in order to have more wild plants and hence promote biodiversity in general. From these structures also a control of some pests by predators living on certain weed species may be expected in the adjacent part of the field.

Since today with modern methods we are able to control weeds very effectively, we might change our strategy from "how many weeds can be tolerated?" to "how many weeds do we need?"

Influence of different cultural practices on the biodiversity of weed species in a sustainable agricultural context

Victor Blandon Rivera
Universidad Nacional Agraria, Apartado 453, Plant Science Program, Managua, Nicaragua

This paper surveys the situation of weed biodiversity in croplands of Central America. From 1987 to 1994, several field experiments were carried out in different localities of Nicaragua and one of Costa Rica in order to determine the influence of cultural practices (tillage systems, crop rotation and different methods of weed control) on the biodiversity of weed species. The results show that the weed biodiversity was strongly influenced by the former use of the cropland, being considerably reduced in those localities where intensive agricultural practices had been done. The diversity of weed species was increased in all experimental sites. Due to the fact that weeds are an essential part of medicinal treatments by local inhabitants of Central America, and are used to control some agricultural pests, more research should be done, and more communication between farmers, peasants, extensionists and scientists should be established before recommendations for weed control are given.

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Sustainable agriculture: An overview of issues, efforts and constraints

V. Ghandimathi
Jayanagar, Bangalore, India

Agriculture is understood to be an activity primarily for food production, and secondarily contributing to trade and other industrial needs. Sustainable agriculture, defined as the continued use of natural resources for the purpose of food and other needs in ways that are ecologically sound, economically viable for the producers and socially just. This article deals with the special case of Tamil Nadu. Tamil Nadu in South India has seven broad agroclimatic zones and has different agricultural production systems, which range from intensive cultivation in river irrigated areas, man made water harvested tank systems, rainfed agriculture and to some extent even shifting cultivation. The crop range from paddy, sugarcane, millets, pulses, gound nut, oil seeds, cotton, vegetables and horticulture crops including tea, coffee and rubber in the hill regions. Small or big farms used to practice mixed farming, including livestock.

Due to the introduction of cash crops, mechanisation and intensive systems of cultivation under the Green Revoultion, there has been severe negative impact on the environment and the social and economic situation of the population dependent on agriculture. In addition, heavy deforestation has added to the environmental degradation, and affected the livelyhood of major sections of the rural population.

Traditional agriculture was characterised by use of traditional and ecologically suitable varities in mixed cropping and mixed farming systems. The primary aim was production of food, and the surplus was traded in the nearby markets. There was much recycling of nutrients and energy. Farmers depended on their own evolved knowledge, and the inputs to the farms from the outside was minimal.

The conventional agriculture is characterised by high external inputs, dependence of farmers on external experts for information and technology, high fertiliser response varities, cash crops and far off markets. Monocropping is common and even in single crops the varities used tended to be uniform varities. The nutrients, like chemical fertilisers, are imported into the farm and exported out of the farm, thus minimising nutrient flow within the farm.

Problems

In the river irrigated wetland areas, adoption of green revolution technology has lead to chemical pollution of soil, water and food material; execessive exploitation of ground water and loss of soil fertility. There has been social and economic problems as well, such as indebtedness among farmers and migration of labour to urban areas.

In the dry land areas, due to deforestation there has been severe soil erosion; reduction in

the water harvesting and percolation capacity, and loss of biomass - essential for the maintenance of soil moisture and fertility. Dependence on cash crops and monocropping lead to intensive use of available surface water and ground water.

Some problems have been addressed by efforts from innovative farmers and NGOs interested in ecological farming, agricultural research institutions and government agricultural extension system. Some solutions have been tried and found useful and appropriate. Some need further development.

In irrigated areas for replacing the use of chemicals, crop rotation, use of organic manure and green manure are possible solutions. For the salinity of the soil: appropriate crops, rotation of crops, and innovative and efficient water use are possible. Plant protection: use of Integrated Pest Management, crop rotation, promoting trap crops, predators, and biological pesticides. For soil fertility loss: mulching, composting, green manure and recycling of wastes are useful.

In dry lands for soil erosion: soil conservation methods, afforestation and cover crops are good way of arresting the damage. For the problem of excessive use of water efficient irrigation methods like pot, drip irrigation, and ground water sharing could be effective. For soil fertility loss: compostion, vermiculture, green manure and mixed cropping, recycling of nutrients and diversity in production and farming could be advocated.

Constraints

Some of the constraints in moving towards sustainable agriculture are
- lack of appropriate technology
- lack of credit for farmers in regeneration and sustainable use of resources
- lack of appropriate and farmer oriented research
- lack of holistic approach among the farmers, especially in resource analysis and planning
- lack of policies concerning water sharing and use, price policies in favour of sustainable agriculture
- lack of suitable farmer oriented extension system and attitudes
- lack of organisation among farmers

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Diversity by design: Conserving biological diversity through more productive and sustainable agroecosystems

Larry Harrington, Natural Resources Group, CIMMYT, Mexico

This paper explores some of the links between agroecosystem biodiversity, productivity and sustainability and the broader ends they serve -- sustainable food security, reduced poverty, improved public health, and conservation of natural biological diversity. In doing so, it first discusses alternative interpretations of biodiversity and sustainability, and then explores two ways to foster diversity within agroecosystems.

Agroecosystem biodiversity involves crop genetic diversity, crop species spatial and temporal diversity, natural biological diversity within agroecosystems, and the indirect effects of agroecosystems on natural biological diversity. (That is, productive systems in one area can indirectly foster natural biological diversity in another area by making cultivation less necessary.) It often is claimed that agroecosystem biodiversity improves system sustainability. This claim is difficult to assess, given the vast number of ways in which sustainability is interpreted. Sustainability would be a more meaningful objective if we could measure it. Unfortunately, most indicators of sustainability are narrowly driven by definitions, leading to arguments that are circular and to conclusions that ignore the *fallacy of scale*.

A classic example of the fallacy of scale can be found in South Asia's Green Revolution (GR), which often has been criticized as unsustainable. At the farm household level, GR technologies may foster low species diversity, reliance on external inputs, environmental pollution, and degradation of soil and water resources. However, at higher levels of analysis, they have been found to be associated with faster economic growth, higher incomes through employment generation, improved income distribution, reduced rates of population growth, and (not least) the saving of an estimated 40 million ha of land from the plow -- or the woodcutter's axe. Resource degradation in GR areas may be a cost of defusing threats to resource quality and natural diversity in fragile, marginal or forested areas. Researchers and farmers must work together to reduce this cost.
If agroecosystem diversity fosters system productivity, stability, sustainability, and improved environmental quality, then how can diversity be increased? One approach is *diversity by design* -- the conscious fashioning of more diverse agroecosystems, intended for widespread adoption by farming communities. This process includes participatory research on indigenous technical knowledge, with a view to extrapolating such knowledge to suitable areas. Unfortunately, research on *diversity by design* typically has not lead to widespread farmer adoption.

Another approach is *demand-led diversification* -- the process whereby higher incomes and reduced poverty generated by more productive agricultural practices shift the structure of food demand towards a more diverse array of products, among them fruits, vegetables and animal products. Farmers follow market signals and diversify their farming systems. Demand-led diversification leads to more biologically diverse

agroecosystems at the regional level, but may or may not ensure increased biodiversity at the plot or farm level.

It is argued that attainment of the overarching goals of sustainable food security, reduced poverty, improved public health, and conservation of natural biological diversity requires a mixed strategy that embraces sustainable productivity improvement in favored areas, sustainable productivity improvement in marginal, fragile areas, and sustainable management of market-led diversification processes. Sustainability is not enough -- productivity must increase as well.

The conservation and use of genetic resources of domesticated plant species

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1. Biodiversity and Genetic Resources: Conceptualization and main differences
The term "Biological diversity" means "the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecossytems". "Genetic resources", on the other hand, is defined as "genetic material of actual and potential value". The conservation of biological diversity denotes policies, legislation and programs aiming at the permanent maintenance and management of the natural communities and populations, that allow for continuing evolution. The conservation of genetic resources focuses on the maintenance of the genetic variability of individuals or groups of species.

The conservation of biological diversity requires the protection of large areas, both public and private, and the establishment of conservation units. Genetic resources are managed in genebanks, both *in situ*, by means of genetic reserves and on-farm activities, and *ex situ*, through the conservation of several forms of reproductive materials, such as seed, embryos, pollen and plants. Genetic resources are components of biological diversity and involve the conservation of the genetic variability of several genrea of plant, animal and microbial species, mainly those used for agricultural and industrial purposes.

Despite great interrelationship and similarities, research requirements for biodiversity and genetic resources are different. Main biodiversity priority areas are evolutionary biology, ecology, ethnobiology, conservation biology, and those related to the classification, taxonomy and inventory of species. Genetic resources main research activities focus on ethnobotany, economic botany, different forms of characterization and premilinary evaluation.

It is also important to note that all countries are dependent on genetic resources for food and agriculture, regardless how rich they are in biodiversity-rich natural areas. This is particularly relevant in developing national and international policies, agreements and legislation aiming at the conservation and sustainable use of biodiversity and genetic resources.

Conservation

The conservation of plant genetic resources is carried out through ex-situ and in-situ methodologies and, ideally, by the integration of both strategies. Different kinds of ex-situ collections (e.g. base, active, field) and in-situ activities (genetic reserves and on-farm conservation) are usually employed by institutionally centralized/ decentralized projects and programs at national, regional and international levels. The magnitude of conservation activities normally requires the active participation of governmental institutions and other major stakeholders of genetic resources, such as NGO's, farming and indigenous communities, private corporations, international organizations and research centers and botanical gardens. Regional and crop networks are also important mechanisms to promote the conservation and use of plant genetic resources.

Genetic resources have been managed through in-situ methodologies, both in protected areas or in farming and indigenous communities. The conservation of genetic resources of target species in protected areas is usually done by the implementation of in-situ genebanks, the so called "genetic reserves", sites for the assessment and conservation of genetic variability of, mainly, priority forest species and wild relatives of cultivated plants. Farming communities and indigenous populations are also playing a strategic role in the in-situ conservation of landraces and varieties of domesticated species. In many countries, networks of farmers have been organized, usually with the participation of NGO's and national programs, aiming at the conservation of genetic resources of staple foods such as rice, wheat, corn and common beans.

Major threats to the conservation of genetic resources are: 1) the loss of landraces kept by farming and indigenous communities. It is estimated that 75% of previous existing landraces related to main food crops have already disappeared; 2) the loss of wild relatives of domesticated species. Two hundred million hectares of natural habitats were converted to specialized agriculture between 1960 and 1980, mainly in developing countries; 3) genetic erosion in genebanks due to poor management of accessions caused by the lack of infra-structure, trained personnel, adequate methodolgy for regeneration and limited financial resources; 4) the level of unwanted duplication of accessions in germplasm collections.

Utilization

An estimated 7000 plants have been utilized in food and agriculture throughout the world. Data compiled from 146 countries show 103 plant species accounting for 90% of the overall national food supply. Genetic resources integrated conservation/utilization strategies are in the center of policies and programs aiming to secure sustainable food production for the increasing human population, that is estimated to reach 8.5 billion in

the year 2025.

The major justification for collecting, conservation and evaluating genetic resources is to ensure their availablity for use in the development of new plant varieties and animal breeds, among other products. An estimate of 650 000 accessions are exchanged per year among national and international institutions and users of germplasm in the world.

Despite the number of accessions maintained by genebanks and the amount of germplasm exchanged in the world, there are several limitations for the utilization of genetic materials by breeding programs. These are mainly related to the lack of characterization and evaluation of data; lack of information on materials existing in both ex-situ and in-situ collections, poor coordination of policies at national level, poor integration of genebanks and users of germplasm; difficulty in handling large collections; small range of species addressed in research activities; lack of market incentives, among other.

In order to improve the utilization of plant genetic resources, genebanks should; 1) increase the quality, quantity and dissemination of characterization and evaluation data; 2) promote the interaction among genebanks and breeding programs carried out by both public and private institutions; 3) promote the development of "core collections", especially for large collections of germplasm; 4) integrate in-situ and ex-situ conservation strategies; 5) develop efficient, safe and streamlined national and international systems for the exchange of germplasm.

Perspectives and problems of sustainable agriculture in Russia

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It is difficult to analyze, and more difficult to forecast, the possible scenarios of agricultural development and land use in Russia. Crisis in the economy and in the social sphere, institutional muddle, chaos in functions of the legislation, uncertainties in land ownership regulations, etc. complicate the identification of main tendencies.

There may be 7 alternative scenarios of agricultural development in the nearest future. The scenarios are as follows:

1. Prolongation (extrapolation) of existing negative tendencies in agriculture - degradation, crisis, production decrease, uncertainty of land ownership rights. In such case the agricultural land area will go on decreasing and being overgrown with forests and bushes.

2. Attempt to raise the agriculture using traditional methods (increase of the earmarked assets from the government, subsidies, cheap credit, increase of using fertilizers and machineries etc). In this case the neglected and marginal lands may be involved in cultivation. This is the extensive scenario of agricultural land use.

3. Structural reformation of agrarian sector and agrarian industry as a whole: rapid growth of infrastructure and processing industries, elimination of tremendous losses of products during transportation and storage. It would provide opportunities for a considerable decrease of agricultural lands (by 20-40%) and increase of final customer consumption of agriculture products. This would be the scenario of intensive agriculture development.

4. Re-orientation of agriculture to stock-raising and decrease of plant-growing. The area of hayfield and pastures would be enlarged, but the ploughland areas would be reduced.

5. Strict environmental regulations in agrarian sector. "Ecologization" of agriculture. Exclusion of most degraded lands from the production turnover with their conservation or using them as meadows, hayfields (like US land conservation program of 1985).

6. The establishment of forest protection zones in agrarian sector for better production mode: against erosion, aridization, for water balance improvement.

7. Global climate getting warmer. Displacement of agricultural production towards the north, aridization and desertification of the most productive southern chernozem regions. Positive climate changes in northern regions. Recovery and development of agriculture in non-chernozem Central and Northern Russia.

The scenarious 3, 5 and 6 (structral reform in agriculture combined with ecologization and institutional changes) are the best for sustainable development of Russian agriculture. They would mean intensification of agriculture and conservation of degraded lands, improvement of the environmental situation and active forest planting. The vast reserve of lands will be formed and kept available for environmental aims (creation of protected areas, biodiversity conservation etc).

Unfortunately, the scenario 1 seems to be most probable for the next 3-5 years. It would mean extrapolation of today's negative tendencies in agriculture stipulated by economic and social crisis in villages, stagnation of agrarian production, and aggravation of the environmental situation in the countryside. Only partial implementation of scenario 2 (governmental support) may be implementable in case of "lefter" political course with minimal economic effect. Scenarios 1 and 2 may be combined: degradation, overgrowing of lands.

Report of Working Group 1a on The Relationship Between Historical Land Use, Cultural Landscape Diversity and the Conservation of Biodiversity

Participants: Janice Jiggins (chairman), Gunilla Almered Olsson (rapporteur), Larry Harrington, Mark Prein, Eva Stattin, Victor Blandon Rivera, Marcio de Miranda Santos, Trygve Berg

Background

Cultural and biological diversity, including genetic resources, are a crucial prerequisite for sustainable agriculture. A thorough understanding of the constituents of sustainability is not presently available but they include cultural processes in which conservation of biodiversity plays an essential role. Knowledge about agroecosystems, and local knowledge and capacity to manage and use diversity in agroecosystems, are complementary aspects of conservation, and essential for the maintenance of long term productive capacity.

There exists a gradient between cultural (human influenced) and natural ecosystems, and between domesticated and wild species. However, natural and agricultural ecosystems in practice to a large extent have become separated and presently occupy different positions on the gradient. Agroecosystems must be allowed to evolve but future evolutionary capacity depends crucially on both cultural and natural diversity being sustained.

Notwithstanding rapid erosion of both cultural and biological diversity, there is in the near to medium term no global problem of food supply. However, agroecosystems which presently are highly productive, in some areas may not be sustainable. Conversely, for some people and some areas agriculture has not developed the potential to deliver income, employment and food security. For these people and areas, the lack of productivity in agriculture also is associated with negative impacts on biodiversity.

The globalisation of markets and the standardisation associated with commercial processing industries contribute to the erosion of local biodiversity. Urbanisation is contributing to the erosion of cultural diversity and creating populations separated from direct experience of agroecosystems (and the understanding of the relationships between food production and natural resources, including biological resources).

Key Concerns

The needs and rights of farmers to exchange, select, breed, use and sell local varieties is essential for the evolution of agroecosystems and conservation of biodiversity. The emerging regime of property rights is not compatible with farmers`needs and rights. Nor does it fit with the institutional arrangements numerous local communities have developed

to safeguard the use and functioning of natural resources, including biological diversity in agricultural landscapes.

Seed regulatory frameworks do not encourage, and in many cases prohibit, the development of farmer-to-farmer seed exchange and trade networks, thus removing an important incentive for the development of local varieties adapted to agroecosystem niches.

The risks and implications of current levels of diversity, including the genetic diversity, of key commodities, in farmers' fields in conventional high input systems, has not been rigorously assessed except for bread wheat. Two questions are of importance: the extent to which sources of genetic variation might have been exhausted, and the extent to which bioengineered products and synthetics might offer new possibilities.

The skills and decisions farmers use in maintaining genetic diversity in their fields, particularly outside conventional high input farming, are only partly documented and understood. The role of farmers, community organisations and others in conserving biological diversity also are not well documented and understood. Recent initiatives demonstrate there are important opportunities for building on the roles of farmers, gardeners and citizens as curators and agroecosystem managers. (see Appendix for examples).

There is limited experience of pooling farmers´ and scientists' knowledge and skills through collaboration in the development of new knowledge, technologies and practices. Recent initiatives demonstrate that the potential and the pay-off of participatory plant breeding are considerable and merit further exploration and investment. (see Appendix for examples).

Integrated Pest Management and other programmes which take an experiential learning approach to supporting or developing farmers' scientific and ecological understanding also are delivering important support to the conservation of cultural and biological diversity in agroecosystems. Further expansion requires development of the capacity of extension and other service providers.

The causality, effects and consequences of known and as yet unknown threats to sustainable production are poorly understood. In this situation, agroecosystem monitoring, and the development of indicators of sustainability, are essential. The knowledge of farmers and other community members is essential for the development, application and interpretation of indicators and monitoring.

Conventional valuation and measurement of yield and other outcomes of production are inadequate for assessment of sustainability trends. Crucially, there is a lack of tools for observing and recording threshold effects which make regeneration of threatened ecosystems difficult or impossible. A number of communities have developed local

understanding of some threshold effects and have identified early warning indicators to prompt remedial action. The world community may learn from and draw on this knowledge.

Recommendations

1. Provide support and incentives to communities and organisations that maintain or generate evolving biodiversity in agriculture.

2. Work to ensure that farmers' needs and rights to exchange, select, breed, use, and sell local varieties are recognised in agreements and in trade-realted Intellectual Property Rights legislation.

3. Allow and encourage pluralism and flexibility in seed regulatory frameworks to permit active framers involvement in exchange, selection, breeding, use and sale.

4. Support further expansion of community-level experiental learning and training in scientific and ecological principles.

5. Promote public awareness of cultural and biological diversity as essential for sustaining food supplies and productive agriculture.

6. Support further exploration and development of the contribution of Farmer-Scientist collaboration in plant (animal) selection and breeding, and in community- and farm-level curatorship of genetic resources and agricultural landscapes.

7. Document, acknowledge, and provide open access to knowledge about existing agroecosystems, technologies, and practices, while ensuring fare and equitable sharing of the benefits derived from use of such knowledge.

8. Support as a matter of urgency the development of tools and procedures for monitoring, and indicators of agroecosystem sustainability, in collaboration with farmers and other resource users.

Report of working group 1b on The Relationship Between Historical Land Use, Cultural Landscape Diversity, and the Conservation of Biodiversity

Participants: Peter Kenmore (chairman), Inga Hedberg (rapporteur), Sergei Bobylev, V. Ghandimathi, Carl Johan Lidén, Peter Matlon, Ulf Svensson, Jane Toll

Theme

In view of existing historical and newly created knowledge in local communities, related to the sustainable use of local agroecosystems, and including extensive knowledge of the components of biological diversity in these systems as expressed in local taxonomies, there is a need for more systematic survey, documentation, and exploitation of that knowledge in both land use planning and technology development. The products of central research institutions have not by and large contributed to conserving biodiversity nor increased sustainability. Local knowledge of agroecosystems is not a universal panacea, but a necessary element in problem solving that is too often overlooked. New initiatives should create opportunities for local knowledge to be informed by scientific concepts, and in turn to inform scientists and make them more accountable to local communities.

Diagnosis

Most bio-physical scientists involved in technology generation are largely ignorant of how farmers view their natural environments in both space and time, how they fit genetic resources and cultural practices to diverse ecosystems, and how farmers value and manage the major components of what modern science defines as sustainability. As a result many new technical interventions relate poorly to farmers' objectives and resources, and fit poorly into their agroecosystems. This matches the modern technical change paradigm dominated by the effort to modify micro-environments through the high use of external inputs in order to fit genetically similar but physiologically and agronomically efficient cultivars. An alternative paradigm acknowledging and preserving ecosystem diversity, and fitting a more diverse set of species and varieties to ecosystem niches may provide the basis of a strategy which simultaneously achieves significant gains in productivity, preservation of biological diversity, and more equitable patterns of adaptation and adoption.

Although the farming systems research and extension (FSRE) paradigm in the 1970s and 80s attempted to respond to this need, it was not accountable to local communities. Often the most useful information was circulated within the disciplinary confines of "farming systems specialists" and was inadequately exchanged with and translated into the disciplinary perspectives of bio-physical scientists and policy makers. Bio-physical scientists and policy makers alike were not aware that they needed such information to

achieve their stated objectives of developing and promoting the adoption of appropriate technologies. The FSRE approach too often viewed farmers as objects of study and largely failed to involve farmers as active colleagues in a process of mutual discovery. Increasing penetration by market forces, distorted policies promoting the inappropriate use of external inputs, and impact of mass media in rural communities have also acted to disrupt local knowledge systems.

This general situation differs in nature and degree in the varying historical, agricultural, economic, and cultural settings of eastern and western Europe, industrializing and agrarian Asia, and Africa. The fundamental problem, nevertheless, of inadequate articulation between the perspectives of farmers' communities and those of the modern scientific and policy communities was recognized throughout.

There exists a serious conflict between short term goals of production per hectare, immediate economic profits, and meeting corporate sales targets on one side and longer term goals of sustainability, equity, and biodiversity. A special problem is the privatization – more often "corporatization" -- of much agricultural extension. It is very difficult for extension agents or advisers working towards fixed targets for sales or coverage to respond to the potential in local agroecosystem knowledge. More inclusive measurement tools, such as total economic valuation of alternative ways of managing agroecosystems, and progressive policy instruments such as taxes based on the polluter pays principle, should be used better to analyze problems and offer solutions.

Response

Past approaches to bridge this gap have largely failed in most areas, so a major structural and conceptual paradigm shift is therefore called for away from the top-down, linear research and extension paradigm to one which can generally be described as agroecosystem based, respectfully collegial and empowering. The actual and potential generation and application of local agroecosystem knowledge is at least as important as its documentation. Although it is can be useful for outsiders to collect, document, and archive information on local communities' knowledge of their agroecosystems, the more active participation in and greater ownership by farmers of all stages in the research and extension process will help ensure that the information is more equitably, directly, and efficiently used. One measure of farmers' ownership under this paradigm should be the formal accountability of research and extension staff to farmers.

Such a paradigm shift has structural implications. It would mean researchers and extension workers would spend more time listening to farmers in groups. Scientists would agree to limit their working attention to local problems, and to accept as working tools the local taxonomies farmers use to understand and manage their environment. In doing so, scientists must realize that communities also have structures. Sometimes these structures can prevent knowledgeable people, especially women and marginal families, from participating fully even if the scientists wish them to participate. Communities are neither homogeneous nor egalitarian.

Based on these premises the following **recommendations** are given:

1. Greater and earlier farmer decision making in defining research priorities, in setting out research approaches, in collaborating with scientists in the design, development, and testing of new technologies, and in evaluating the research process and researchers. As an example, the group strongly endorsed expanded use of participatory varietal selection and participatory breeding.

2. To achieve this, forums would be set up and maintained for farmers, researchers, and extension workers to meet, discuss, debate on a "level playing field" that creates an atmosphere for the two-way flow of information and promotes a dynamic and truly participatory process. These forums should be designed and supported through pilot schemes, which will form the bases of good case studies, where major partners are brought and funded together not only to identify and solve locally important problems, but to work out new and better ways to maintain dialogue and constructive criticism.

3. To initiate these forums appropriate and location specific entry points shall have to be identified as a function of local problems defined by farmers' communities. Examples of these entry points for forums are quite diverse, and include:

- soil nutrient deficiency that can be documented by farmers for their community's use in deciding on intervention, and understood in terms of basic concepts of nutrient pools, flows, recycling, and crop response (potassium and phosphorus deficiencies in rice in Cambodia);

- soil erosion in over-used topographies where a range of ameliorative actions are possible (Burkina Faso);

- improved crop management of a secondary food crop to capture sporadic market "windows of opportunity" (sweet potato in Indonesia);

- better mixtures of high potential yielding varieties to match local agroecosystems (beans in Rwanda and neighboring Great Lakes countries in East Africa);

- varietal diversification as a new strategic path for managing genetically complex pathogens (rice blast in Central Vietnam);

- crop diversification to respond to market forces and new opportunities (fish culture in Asia and West Africa);

- amelioration of soil compaction after de-collectivisation in newly divided farm units (Russia arable crops);

- scaling up of crayfish production in response to newly opening markets for rice growers (Southern USA); and

- integrated pest management where insecticides have induced key pest outbreaks (cotton in Asia, Africa, and America).

4. An important benefit of the forums to farmers would be increased access to scientific concepts and principles that could be applied to new problems beyond the entry points. This shall require careful attention to the process of dialogue in the forums. New information brought by outsiders as their contribution to the ongoing process of defining and solving local problems should be in the form of observable principles, and not through the presentation and promotion of particular technologies or packages.

5. A core activity of the forums therefore will be to develop well adapted solutions and solution-finding strategies for locally defined problems by pooling local knowledge generated by farmers and outsiders' "scientific" information. To facilitate an equitable pooling of ideas, there is a need to identify and characterize local agroecosystems from farmers' own functional taxonomies that define different soil, climate, edaphic conditions, and basic resource profiles. These reflect experiences of the communities across seasons as well as among fields. As new, pooled knowledge about local agroecosystems is constructed, it will become more possible to suggest ways to select, test, and fit new cultivars, cultural practices, and diagnostic tools for decision making to specific agroecosystems.

6. This forums initiative should try to make an impact on research and extension institutions, through their staff who join farmers in the forums. This is not limited to "feeding up" specific technical solutions to local problems to enlighten isolated laboratory staff. It should rather contribute to a better way to think about research priorities, and help balance the public and private bureaucratic inertia that constrains possible avenues of exploration. In particular, most work with GMOs has been largely irrelevant to problems identified by small scale farmers. Similarly with pesticide R&D, large market segments (such as large scale industrial crop growers) dominate decision making. This initiative should stimulate and document the impact of the forums on large agricultural institutions through changes in the perceptions and new directions of their staff.

Report of the working group on "Towards sustainable agriculture - how to achieve realistic scenarios in short and long-term perspectives".

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Introduction and background

The notion of sustainability was expressed in many different forms. These for the most part took two forms - the recirculation principle, and the concept of sustainable growth to meet human needs. The former stressed the sustainable use of resources (in order to ensure the integrity and long-term functioning of agroecosystems) while the latter stressed the sustainable achievement of outputs. Both are closely related. It was stressed that the local situation must be kept in mind when assessing sustainability - that sustainability can mean different things in different contexts. Aspects of sustainability that were mentioned include:

- recirculation principle
- sustainable use of energy, nutrients, soil and water resources
- productivity of natural capital (resources) should not decrease
- maintenance of biodiversity for ecosystem functioning and integrity
- sustainable development or sustainable growth
- sustainable productivity growth requiring the conservation of resource quality
- food security for the community
- life quality for farmers and farming communities
- sustainable livelihoods and incomes, and not necessarily only from agriculture
- economic viability for farmers
- adequate output of food, energy and raw materials to meet human needs
- social justice and equity

It was recognized that sustainability is a broad concept that can have different meanings for different people and that a sensible discussion of sustainability requires some common ground - an agreement on what is to be sustained. Three major interpretations of sustainability were noted from one of the introductory lectures:
- sustainability in terms of agroecology and the recirculation principle,
- sustainability in terms of ethics and the need to maintain resources for future generations, and
- sustainability in terms of the need to foster sustainable food security for a growing human population.

In a related manner, and from materials drawn from another lecture, it was recognized that for a food production system to be sustainable, it needs to be ecologically sound, economically viable, and socially just.

Examples and discussion

Case studies and examples were used to try to find a common ground to link biodiversity and sustainability of agroecosystems. Examples of threats to sustainability - and indicators of progress towards sustainability objectives - were given for Sweden, Netherlands, India, Tanzania and Russia.

Sweden - concerns emphasized conservation of the cultural landscape (and the conservation of the functioning of agroecosystems), the threat to species that have coevolved with agroecosystems posed by the possible expansion of spruce forest, the consequent possible reduction in biodiversity, the negative externalities (in fertilizer producing countries) associated with fertilizer imports and the possible benefits associated with reducing imports of fertilizer and using locally-produced manure in its place for agricultural production purposes. This may require subsidies for environmentally friendly practices, including organic farming. Another issue is how to foster greater recirculation of nutrients between urban and rural areas.

Netherlands - concerns emphasized the high environmental costs associated with an intensive agricultural system based on large scale feed imports and extensive export of livestock products. Environmental costs were seen as including pollution within the Netherlands, leading to social issues (e.g., reduced use of beaches and rivers) and reduced aquatic biodiversity (associated with lower water quality) -- and also nutrient depletion in those countries specializing in the export of livestock feed to the Netherlands (e.g., cassava-producing regions of Thailand).

India - concerns emphasized the need to stop or reverse soil and water degradation that threaten future food security for a growing population. Examples that were given included groundwater depletion and soil fertility loss, and the loss of biodiversity stemming from earlier efforts at intensifying farming systems for foodgrain production. Technical change (introduction of more complex cropping patterns and farming systems, reduction in the extent of monocropping, adoption of more water-use-efficient rice irrigation practices) as well as policy change (adjustments in water or electricity pricing to encourage more rational use of water resources) were seen as needed.

Tanzania - concerns emphasized the degraded state of many agroecosystems that have reduced productivity to precariously low levels, and the need to recapitalize some system components (e.g., soil phosphate levels) before the recirculation principle can take effect. Even N fixing species have a hard time surviving in agroecosystems that are exceptionally degraded. It was recognized that the recirculation principle is difficult to apply when there is little to recirculate (in this case a particular kind of nutrient). Other concerns emphasized the reduced capacity of less diverse agroecosystems to cope with weather-related uncertainty.

Russia - concerns emphasized the withdrawal of land from agricultural production

(abandonment), environmental degradation including erosion and land compaction from heavy machinery use, reduction in grain production and corresponding concerns about food security. It was suggested that interventions or solutions might take the form of environmental regulation for land conservation, the introduction of erosion control practices, the creation of land reserves for biodiversity conservation (forest protection zones or sheltered belts), increased use of organic fertilizers, etc., -- all of this in the context of great institutional and policy flux and uncertainty.

It was recognized that (despite the differences in concerns and issues in the four countries), the extent of biological diversity can provide a useful indicator of progress towards productivity and sustainability goals.
- In Sweden, diversity serves as an indicator of the extent to which treasured endangered species have been conserved.
- In the Netherlands, diversity serves as an indicator of the extent to which pollution from intensive production is damaging the environment.
- In India, diversity serves as an indicator of the extent to which the threats to resource quality are being met through more productive and diverse systems.
- And in Tanzania, diversity serves as an indicator of the extent to which agroecosystems are collapsing (or regenerating) in association with soil fertility changes.

It was also recognized that there a number of elements of concern that are common to all countries, for example, how to manage intensive production systems in a more environmentally friendly, sustainable manner, with a more effective application of the recirculation principle. Green Revolution areas of India and intensively farmed areas of Europe share this concern.

A logical chain was generally accepted - that the sustainable use or management of biological diversity can lead (along with other management practices and policy changes) to improved agroecosystem sustainability and productivity and that this in turn can foster the conservation of wild biological diversity, both within agroecosystems and also in ecosystems less influenced by human action.

There was considerable debate about the nature of a possible trade-off between agroecosystem intensification and extensification - the extent to which intensification may help avert extensification - for forests and fisheries as well as for agroecosystems. It was felt that this trade-off in general was poorly understood - but potentially could prove to be exceedingly powerful.

Economics concepts may be a useful conceptual framework - the value of a biological resource is the sum of direct use values, indirect use values, option values (e.g., insurance relative to a possible future use for a resource), and existence values (the inherent value of a resource apart from its usefulness to humans).

At a more global level, a chain of causality was hypothesized, whereby population

growth, urbanization, and income growth (with a corresponding change in consumption patterns) all placed pressure on resources and unsustainable use of these resources. Some concern was also expressed relative to the effect of regulations that restrict the diversity of products to consumers (e.g., a few kinds of apple varieties within the EU). Some possible intervention points, then, are to:
- slow population growth
- slow urbanization
- intensify production of agricultural products
- extensify production
- tax consumption or otherwise discourage extravagant consumption patterns
- deregulate food categories
- stimulate local self-reliance in food production
- change food system/ distribution policies to foster greater diversity and lower ecological and environmental costs.

There was considerable apprehension expressed relative to the nature of the global feed/ food trading system, particularly with regard to its fragility and riskiness (of production of export), and the ecological costs in producing and consuming regions as well as the ecological and energy costs of transport systems. (Howevere, the nature and extent of trade-offs between alternative production locations was not discussed.) However, there was also a concern that reducing or eliminating food trade would result in reduced food security, higher food costs for poor consumers, greater poverty, and less efficient production - and possible at a higher environmental cost, as production may be forced into areas where it doesn't belong. The area of global trade remained contentious.

Recommendations

Recommendations related to policy change

- Use selected policy instruments to foster the conservation of socially valuable biodiversity. Given the presence of externalities, and the inability of markets to account for the value of resources outside of their direct use value, policies can be used to provide incentives to foster socially valuable biodiversity conservation in different settings. Policy instruments include taxes, subsidies, regulation, and the various kinds of policies affecting property rights and asset distribution and use.
- Introduce policies to foster the more sustainable and productive use of common property resources - policies that govern common property management (community forests, groundwater reserves) can be particularly useful in instances where collective action is needed to achieve sustainable resource use.
- Introduce policies to govern the relationship among land owners and tenants, where tenancy or access relationships discourage productive and sustainable land use.
- Promote representation of NGOs and environmental groups and farmers' organizations in policy making at national levels
- Consider the implementation of a land tax to encourage the withdrawal of marginal

land from cultivation.

- Note the difficulty in implementing some policies, e.g., taxes, in areas where tax evasion is high or where policies are otherwise difficult or impossible to enforce.

Recommendations related to the design of technical change

- Promote interaction between rural and urban areas in terms of recirculation of nutrients.
- Promote the adaptation of agriculture to local conditions through greater interaction among farmers, researchers and NGO staff and extension workers.
- Support the wider application of principles of integrated resource management (IRM) which comprise the strategies of organic farming, lower external input, and sustainable agriculture (LEISA), and integrated farming systems - in ways that foster improved productivity and the ability to meet human needs as well as the conservation of soil and water resources and biological diversity.
- Establish forest reserves in villages to maintain a diversity of forest species, and encourage sustainable use as a strategy for conserving valued and endangered species.
- Promote ecological planning of agricultural landscapes.
- Foster the development of ecotourism, game parks, and a wide range of other rural activities to generate employment and incomes, particularly when these may be good complements to agricultural production as such.
- Facilitate the use of refuge areas (roadsides, railroad rights of way, cemeteries) to conserve biodiversity than otherwise may entirely disappear from a landscape (although it is recognized that this is not a good substitute for sustainable management of a resource - but sustainble management is not always possible).
- Design new agroecosystems that foster the conservation endangered species, with a particular emphasis on the functioning and integrity of agroecosystems in their dynamic, evolutionary context

Recommendations related to education and public awareness

- Invest in the education of farmers, to facilitate more rapid and widespread adoption of productivity-enhancing resource-conserving practices such as IPM.
- Help improve consumer awareness consumers relative to food production and biodiversity issues, and the "greenness" of the products they choose to consume.

Report of working group on The Conservation and Use of Domesticated Species

Participants: Trygve Berg, Inga Hedberg, Janice Jiggens, Peter Matlon (chairman), Ulf Svensson, Marcio de Miranda Santos, Peter Westman (rapporteur)

Background

Current practises for the conservation, exchange and utilization of genetic resources may inadvertantly result in reduced genetic variability of domesticated species. The global genetic resources system is disaggregated into at least six functional components within which specific recommendations for action are addressed. The aim of these recommendations for action is to promote the sustainable utilization of more diverse and productive genetic materials by a broadened spectrum of users.

Recommendations

Conservation

1. Support farmers' efforts to establish networks for the on-farm conservation of genetic resources. Support should facilitate communication and linkages with ex-situ conservation systems, re-introduction of material as necessary, and creation of working linkages with participatory selection breeding breeding activities.

2. Encourage national programmes to commit resources towards the integration of on-farm and ex-situ conservation activities. Integration will involve the two-way exchange of materials as well as information on germplasm characters and seed technologies adapted to local requirements.

3. Identify gaps in current collaboration for the conservation and utilization of genetic resources and promote collaboration where significant gaps occur. Priority should be given to species which have a wide geographical distribution, which reflect a high level of germplasm interdependence and which have global significance as food staples.

4. In order to improve efficiency in the conservation, characterisation and utilization of large collections, promote the development of core collections at the global level through the identification of accessions maintained by diverse institutions.

5. Conduct an inventory of best practises for local in-situ conservation both in natural areas and on farm and diseminate information of these practises and resulting guidlines to potential users globally. Identify other priority constraints that are limiting in-situ conservation that can be addressed by international and national communities.

6. Promote the broadening of collections and conservation efforts to ensure inclusion of underutilized species.

7. Promote the establishment of genetic in-situ reserves for relatives of domesticated

species threatened with extinction. Special attention will have to be given to those species for which effective ex-situ conservation technologies not are available.

8. Promote research to develop and improve the efficiency and cost effectiveness of ex-situ conservation methods with emphasis on recalicitrant seed and vegetative propagated species.

9. Increase investments to create or strengthen national and regional genetic resource programmes. To maximize their value, these programmes must be functionally integrated with agricultural research, development and extension agencies, as well as with farmer communities and organisations.

Exchange

10. Germplasm linked to food security must be freely available to bona fide, users including farmers, for research and development purposes. Any existing or proposed IPR regime must conform to this principle.

11. Support and promote the exchange of germplasm among farming communities.

12. Promote collaboration between farmers and collectors within national programmes in a two-way exchange of germplasm information.

13. National breeding programmes should be encouraged to nominate more of their materials to international nurseries coordinated by international research centres in order to broaden the genetic base of material under evaluation.

14. International agreements for the exchange of genetic resources for food and agriculture must be urgently developed to encourage a broader exchange of genetic resources.

Breeding

15. Public institutions must promote and continue to conduct and fund breeding activities to provide a counter balance to the growing power of private sector firms and to ensure that social goods continue to be provided.

16. Conduct an inventory of best practises used in farmer participatory varietal selection and breeding, and disseminate such information to potential users globally. Identify constraints in the successful application of these methods and conduct adaptive research to improve them.

17. Encourage research in food processing technologies to encourage a broader utilisation of crops of low commercial interest. Orient breeding more closely towards post-harvest characteristics.

18. Promote broadening of the genetic base of breeding populations.

19. Expand the use of landraces, closely related species and wild relatives in applied breeding programmes.

20. Support the development of appropriate national biosafety regulations, human resources and institutional arrangements to promote the safe movement of GMOs.

Release

21. Re-examine national seed release regulations and, when necessary, modify them so as to:

a) permit multiplication and dissemination of segregating populations to allow further development in farmers fields.

b) revise varietal release criteria to include information from farmer assessments.

c) remove criteria which require broad geographical adaptability at the expence of fit to local ecological conditions so as to ensure the release of materials with superior performance in specific environments.

d) allow alternative seed supply systems to exist legally.

Extension/development

22. Support service providers to promote the use of a wider range of cultivars adapted to diverse agro-ecological conditions and farmers' preferences.

23. Promote institutional changes to allow pluralism in the provision of services to farmers and decentralisation of public extension and development services.

24. Support mechanisms which increase the accountability of extension and development service providers to farmers.

25. Promote participatory selection of varieties with the full involvement of breeders, farmers and extensionists in order to promote the rapid and targetted dissemination of genetic materials and to increase the motivation of extension field staff.

Information/Exchange

26. Improve the dissemination of genetic resources information including quantitative and qualitative characteristics percieved by farmers and other users. Broad access to such information to farmers and other users must be assured.

27. Support farmer-to-farmer exchange of information and genetic material.

Report of working group on Use of Chemicals (including nutrients) in Agriculture and its Impact on Biodiversity

Participants: Ann-Marie Dock Gustavsson (chariman), Victor Blandon Rivera (rapporteur), Peter Kenmore, Dan Simberloff, Karl Hurle, Barbara Ekbom, Ulrika Askling

The following questions were discussed:

1. How many pesticides and commercial nutrients are used in the world, and in what quantities and how are they distributed?

2. How do these substances influence biodiversity - direct and indirect ?

3. What can be done to minimize the need for pesticides and commercial nutrients in agroecosystems?

4. How can extension services minimize the need for commercial chemicals in agriculture?

1. Data about the country-specific and product-specific use of pesticides (insecticides, herbicides, fungicides, nematocides, fumigants, rodenticides, growth regulators, mycopesticides) are currently not available. Chemical companies are seemingly maintaining these data as a commercial secret and are not willing to share this knowledge with the public. We would like to recommend that these data be open to the public in order to get information on issues like the basic formulation of substances used, the market value and especially their value in US Dollars, active ingredients, the target crop and the surrounding ecosystems these substances are used on, as well as the magnitude and area these chemical substances are spread over.

Despite the problem of data unavailable from the chemical companies we would like to refer to the paper of David Pimentel on the use of pesticides worldwide, the Industry Standard Survey on Fertilizers and other Substances (USA) as well as to information of the FAO Conference on nutrients.

In some countries of the world pesticides like DDT, Aldrin, Dieldrin, Atrazin and 2,4,5-T are banned, but are applied without restrictions in third world countries. As an example of this we would like to mention that the same year the USA banned DDT, a DDT plant was built in India. The FAO Conference adopted a Code of Conduct (voluntary) on the distribution, sale and application of pesticides in 1989. But still there is a need of strengthening the Secretariat at the FAO Conference on this issue. One conclusion is that the governments of pesticide producing countries must be sensitized

to this issue. Better dissemination of knowledge on these substances is necessary to raise awareness in general.

2. Examples for effects of pesticides on biodiversity were discussed. Small islands and their surroundings (coral reefs, marine life) are very susceptible to the impact of pesticides as they are very fragile ecosystems. The application of these substances on small islands can bring about an extinction of some endemic species, spraying of fields and transportation (by wind and water) of those substances into the water may be fatal for larval coral organisms. It was reported that fishermen on the Philippines used insecticides to stun coral reef fish in order to catch and then sell them.

There must be an attempt to reduce and specify the use of pesticides globally.

How do these substances influence biodiversity:

- soil fumigants like methylbromide have effects on the atmosphere thus having a potential of affecting biodiversity
- forming of resistance by hybridisation
- contraction of range
- kill a whole range of non-target organisms including endangered species
- susceptibility to a pesticide influences genetic resources
- broad spectrum of toxicity to mammals and non-target plants and animals
- kills insects (non-target) whose predators will be affected as well
- suppresses the immune system of birds, mammals and thus reduces biodiversity as well (sublethal effect)
- building up resistances to herbicides, this bringing about losses in diversity of pest populations.

Studies on the effect of pesticides on the soil microflora show that many of these substances do affect the soil microflora, but it apparently recovers by the end of the season. The researchers tested the number of organisms, cellular activity and the effect on their nitrogen cycle. Field experiments carried out in Nicaragua showed that herbicides reduced the population of *Bradyrhizobium* resulting in a lower number of nodules in soybean, but not significantly (in comparison to other weed control methods). However more research in this field should be done.

Nitrogen fertilization has side effects on the vegetation and establishment of certain species in the weed community. Under tropical conditions it promotes the Poaceae species and under temperate climate species such as Chenopodium album.

3. Formal and non-formal education must be the basis for minimizing the use of pesticides and mineral fertilizers in agroecosystems. It is common knowledge that a balanced and healthy crop rotation combined with IPM can help reduce the

consumption of pesticides. Apart from this we also suggest that research should be conducted to evaluate the population ecology of pathogens, insects and weeds, and develop reliabel methods for diagonsis in order to regulate these species (can be done in the major food and fibre crops). An example for this is *Echinochloa crus-galli* in rice and *Bemicia tabaci* (white fly) as a pest.

It is essential that ecologists and agronomists cooperate to help break the practice of application without preliminary evaluation to minimize the use of pesticides. Also politicians should talk directly to farmers in order to receive an immediate communication. Formulate an action program that focusses on certain crucial facts as for eg reducing the risk by means of reducing the quantity of substances applied. Work on different levels: education (introduce ecology as a subject for agronomists), technology and make use of existent policy legal devices, including taxes.

Use IPM with the goal "use as little chemicals as possible" or rather look at IPM as an integrated Plant Nutrient or Production Management System. Approach problems from an agroecosystem point of view.

Farmers need to be educated more on the hazards and use of pesticides, on safety , the ecologic and agroecologic threshold. There should be a certificate for farmers in order to buy and use these chemicals. Farmers need to discover how fragile the ecosystem actually is and the responsibility they have. An agroecosystems specialist should be consulted before a crop is treated with a pesticide, at least if very ecotoxic compounds are used. There should as well be a special permit or prescription from such an expert, licensed by apropriate authorities for instance Propanil in California can not be applied without prior permission (license).

We recommend the acquisition of more knowledge on the ecological effects of chemicals designed by the companies.

Some figures might aid the understanding of the current situation:
- around 30 billion USD are spent annually on pesticides (sale value),
- 3 billion USD are destined worldwide for pesticide research by chemical companies, which leads us to the conclusion that there is a need for governmental measures to cut down on the application of these substances, for research into a more useful direction and for thought about the introduction of the "polluter pays"-principle. Public awareness on this issue needs to be raised.

In many countries crop residues are not used as fertilizers and they are removed from the field although they could be a good natural source of nutrients for the next crop (residues of Phaseolus bean).

To reduce and optimize the use of fertilizers, the real nutrient demand of the crop should be measured before applying the chemicals. Easy to handle test kits should be developed and used by the farmers, thus avoiding excess use of chemicals.

The use of green manure could also be a good contribution to reduce the consumption of commercial nutrients, as well as recycling of nutrients from city waste.

4. The first step is to strengthen the human capacity in extension services. These services should be oriented towards a reduction of the chemical impact on the environment and not market oriented as it has been until now. Furthermore extension should have an educational approach, for eg on the Seychelles ecological training on the use of fresh water was given to school students at a very early age. The environmental education should also comprise teaching "non-farmers" and the final consumers of agricultural products. Concepts have to be found in order to get farmers together and find a viable way of doing things. But after all, it should not be forgotten that farming is a business.

Report of Working Group on Effects of Agroecosystems on Native Biodiversity

Participants: Karl Hurle (Chairman), Barbara Ekbom (Rapporteur), Dan Simberloff, Torleif Ingelög, Ann-Marie Dock-Gustavsson, Peter Westman, Ulrika Askling, Linda Hedlund, Urban Emanuelsson.

Background

The role of the group was to illustrate threats imposed on natural species by agricultural activities and to propose ways of minimizing or eliminating these risks. In addition possible benefits of agricultural practices for maintaining and/or increasing biodiversity were considered. The importance of biodiversity for sustainable agroecosystems was also discussed.

The group began by discussing what the definition of agroecosystem should be. We concluded that an operational definition would be: Land used for agricultural purposes and habitats maintained by agricultural activities including grazing and grazing in semi-natural habitats.

It is difficult to prove that sustainable agriculture depends on high species level diversity. However, it is equally difficult to prove that high species level diversity is not important for sustainable agriculture. There are many good ethical, aesthetic and cultural reasons to preserve biodiversity. The economic and ecological consequences of decreased biodiversity on sustainability in agroecosystems are, however, still unclear. It will be extremely important to formulate testable hypotheses that can illustrate the effects, both positive and negative, of maintaining or increasing biodiversity. The group concluded that biodiversity of habitats is desirable for sustainable agriculture.

The impact of biodiversity on sustainable systems is partly a question of scale. Biodiversity may have little or no impact within a single agricultural field or in a pasture. Energy and/or nutrient flows are probably more important for sustainability at a field level. At a habitat/farm level increased biodiversity may be important for exchanges between habitats because organisms that require varying habitats for different activities (reproduction or foraging) can be encouraged by more variety on a farm level. Pollinators and natural enemies of plant pests are examples of beneficial organisms that may be increased by habitat biodiversity. On a global scale maintenance of biodiversity is extremely important so that genetic resources will be available for future generations.

Species / Habitats dependent on agricultural activities.

Agriculture necessitates deliberate and recurring disturbance of or interference with natural habitats. This does not mean that agriculture will necessarily reduce biodiversity. In fact, dependent on scale, agriculture can even increase biodiversity.

Some species absolutely depend on agroecosystems for their continued survival. Examples of wild species dependent on agroecosystems are early successional species or pioneer species; in general, invaders of disturbed landscapes. Ploughing and other cultivation of the land, fertilization and the open conditions that increase light and heat are all factors that characterize agroecosystems. Soil disturbance is essential for many species of annual weeds, fertilization encourages plants such as *Chenopodium album*. Some plants and insects such as butterflies are encouraged by open, light conditions. Grazing and browsing can profoundly affect plant species composition. In some parts of the world whole vegetation communities have been formed by domesticated grazing. Ungrazed areas can, in some cases, quickly be dominated by a few highly competitive plant species.

Agricultural practices can create and maintain habitats for wild species. Streams, wetlands, solitary trees, copses, hedgerows, gallery forests and ditches are all examples of habitats indirectly associated with agriculture. All of these habitats contain species that will be threatened if the habitat disappears. Some species of sand pipers will become extinct as grazed marsh meadows are eliminated. Populations of, for example, partridges and pheasants would plummet if ditches and hedgerows are removed.

Some species live partly outside of agricultural fields but are dependent on them for foraging activities. These species will often use forest areas for nesting sites and move into open areas to find food. Birds such as honey buzzards, bats and insects such as wasps are examples of species maintained in this way by agroecosystems.

Threats to species caused by agricultural practices

It is important to remember that species and habitats that are not even closely associated with agroecosystems can also be profoundly affected by agriculture practices. Some of the threats imposed by agroecosystems include:

- Transport of nutrients in water and air. Nitrogen leaching may change nitrogen poor environments into nitrogen-rich environments and thereby change species composition. Nitrification causes changes in large sea beds. Changes in terrestrial systems can be caused by nitrogen pollution, destruction heathland habitats in Holland are an example.

- Transport of pesticides in water and air. This may result in direct poisoning of some species, for example many fish are very sensitive to insecticides and fresh water mollusks to pollution of all sorts.

- Loss of top soil by wind and water- soil erosion. This will cause sedimentation in the water and can affect freshwater mollusks and marine corals negatively.

- Crops that become invasive in new areas / hybridization. Introduction of new crop species for cultivation or for ornamental use may result in native species being

endangered by severe competition. Newly introduced plants may hybridize with native species and thereby threaten them, e.g. commercial *Helianthus annuus* sunflowers and endemic candidate endangered species of other *Helianthus*.

- Transgenic plants: for example plants into which *Bacillus thurengiensis* or herbicide resistance has been incorporated. Outcrossing of transgenic plants with native plants may incorporate new characteristics into native plants with potential ecological consequences.

- Biological Control attempts: Novel species introduced into an area to control a particular pests may begin to attack non-target species and reduce or threaten native species, e.g. the little metalmark butterfly, host-specific to a native thistle in North Carolina that was devastated by a weevil introduced to control a non-indigenous pasture thistle. The seven-spotted lady beetle introduced into the United States for aphid biocontrol has threatened native species of lady beetles through competition.

- Expansion of agriculture usually results in the destruction of wild habitats such as savannas and wetlands.

- Withdrawal of water from wild habitats for use in agriculture can threaten endemic species, e.g. the Ogallala aquifer, Florida aquifer affects the Everglades National Park.

Effects on organisms directly associated with agroecosystems:

- Changes in agricultural systems for example the removal of grazing from farm systems can reduce species biodiversity (introduced weeds can explode and outcompete native species).

- In areas adapted to grazing extensive overgrazing can threaten native plant species

- Feral livestock (pigs, goats) threaten extinction of many plant species. This is also true for other livestock, cattle grazing has caused a threat to native perennial bunchgrasses of the intermountain west in the US.

- Mechanization may kill organisms living in the field.

One major conflict is that high intensity agriculture for maximum production often stands in direct conflict with biodiversity goals. Current trends include high intensity input on small land areas or lower input but on a more extensive scale. The first alternative is dependent on high use of agrochemicals and fertilizers that affect surroundings negatively. The second alternative decreases and fragments land available for habitats important for wild species.

Recommendations for action:

1. Landscape management to increase biodiversity can be implemented. Questions concerning the optimal sizes and distribution of habitat patches for native species must be answered. It is important that landscape composition be adjusted to local situations. The creation of new habitats and reconstruction of lost habitats are possible components.

2. No tillage zones along waterways have been shown to reduce sedimentation, leaching of nutrients and runoff of pesticides. Buffer zones and conservation headlands can be used to maintain some organisms. Recommendations for size and evaluation of effectiveness of these types of zones should be investigated.

3. Minimizing use and increasing efficiency of agrochemicals and nutrients is desirable for increasing biodiversity.

4. Legislation to restrict import of exotic species and gene-manipulated organisms is required. An alternative to a 'black list' of species which may absolutely not be introduced into new areas would be a 'white list' of species that can be considered innocuous to native biodiversity. A protocol for determining the biosafety of organisms should be developed.
4.1 Eradication of harmful feral livestock is possible, e.g. "Judas goat" technique has been used in many places, also intensive combinations of hunting, trapping and poison.

5. Incentive packages for implementing habitat management systems may be more effective than disciplinary programs.
5.1 Education programs for both farmers and consumers should be prepared. Awareness of endangered species through 'red lists' and accomplishments in species preservation using 'blue lists' are important components.
5.2 Incentives should include programs to allow individual farmers and farming communities to reap some of the benefits of increased wildlife biodiversity (e.g. hunting, fishing and ecotourism).

6. Analysis of both risks and benefits of changes of agricultural practices should be put into the same currency. Both spatial and temporal time scales should be comparable.

7. Traditional grazing and browsing in semi-natural habitats without fertilization and pesticides should be encouraged and supported by societies in Eurasia.

8. The possible relationship between agroecosystem nutrient cycles and native biodiversity should be studied.

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Biodiversity and sustainable agriculture

14th - 17th August 1996
Ekenäs, Sweden

A workshop arranged by the Swedish Scientific Council on Biological Diversity focusing on the importance of biodiversity for sustainable agriculture.

The Swedish Scientific Council on Biological Diversity has initiated a series of discussion papers, aimed at discussing topical questions in biodiversity, such as conservation and sustainable use of biodiversity and its components. The series will be open to all issues related to biodiversity, but priority will be given to topics of common interest, including sustainable use of biodiversity and its components. It is not a forum for publication of original scientific results. Contributions should be discussion papers, and topics may reflect different views within the scientific community. There will be space available for communication and replies to papers in the series, or discussion on controversial issues, are encouraged.

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